MuLAN: A Precision Measurement of the μ^+ Lifetime

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The Fermi constant G_F is a fundamental parameter of the Standard Model which determines the strength of all weak processes. Due to recent theoretical efforts, the dominant uncertainty in G_F is now in the experimental sector.

The goal of the MuLAN (MUon Lifetime ANalysis) experiment is a 1 ppm measurement of the positive muon lifetime τ_{μ^+} at the Paul Scherrer Institute (PSI). This would represent a 20-fold improvement over previous efforts, resulting in a G_F precision of 0.5 ppm. The experiment requires a high-intensity pulsed muon beam, a nearly hermetic decay spectrometer, a high-precision clock system, and a fast DAQ to obtain the necessary statistics.

FIG. 1: The finished MuLAN detector ball made from 170 triangular shaped double-layered scintillation counters. 6 (5) counter units form hexagonal (pentagonal) shaped building blocks.

We reached several milestones in 2003:
- An electrostatic muon kicker and associated high voltage network were assembled and used for the first time.
- We have found a beam tune for our optimal 12 MHz surface muon beam flux with a $\sim$1 cm^2 beam spot and a parallel beam transport through kicker and separator.
- The construction of the MuLAN "soccer ball" detector was finished (Fig.1) and all scintillator elements were tested.
- All detector modules are now equipped with Berkeley-designed fast LED-flasher boards, which allow us to apply a computer-controlled flash pattern.
- The newly-developed, MIDAS-based, high-rate DAQ system was successfully tested.

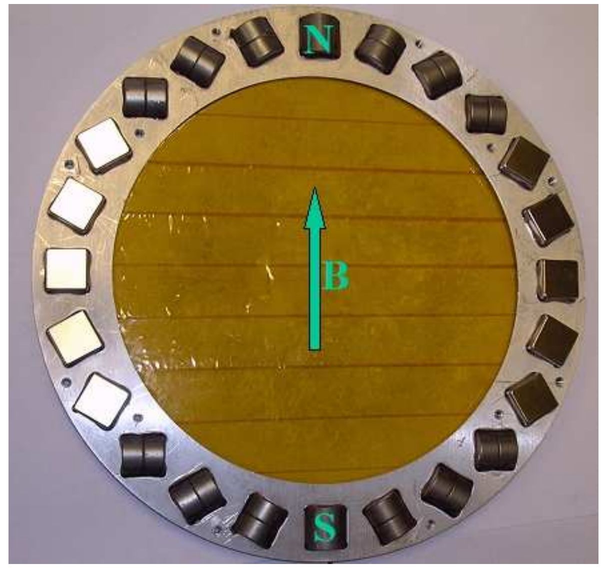

FIG. 2: The μLAN target-station: A 20 cm diameter sulfur target inside a Halbach type magnet with 128 Gauss central field.

- A prototype 500 MHz wave form digitizer board was built. They will be used to record scintillator signals and distinguish electron pile-up events.
- Several different target options were investigated.
- The detector was comissioned in the fall 2003 run, when we obtained the first τ_{μ^+} data.

The muons following pion decay are highly spin polarized when they enter the target and precess in the earth's magnetic field. Their decay electrons are preferentially emitted in the muon spin direction. Consequently the decay electron detection in our detector depends on location and time. We try to control this effect by depolarizing the muons in the target with materials like sulfur and by spinning the μ^+ in a uniform magnetic field with known frequency. Fig.2 shows the Berkeley-built target station with one of the sulfur targets. We also tested a new target material with very high internal magnetic field ($\sim$1 T) and found no observable μSR effect.

We plan to have a first data-taking run in fall 2004 which aims at an understanding of systematic effects and a precision of a few ppm in the muon lifetime.

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